Design, Fabrication and Performance Evaluation of a Three-Phase Poultry Bird De-Feathering Machine

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Abstract- A poultry bird defeathering machine was designed and fabricated. The machine consist of a feather plate on which rubber pluckers were arranged, a defeathering chamber on which rubber pluckers were set in an array and was powered with a 1.5kW electric motor. A single-phase (defeathering chamber) of the machine was tested at three operating speeds of 200, 280 and 360 rpm, the variation in speed was achieved with a variable resistor system and also by varying the pulley diameters. In order to evaluate the effect of rotor speed and scalding temperature on feather retention, plucking efficiency, and the defeathering time. Isa brown chickens which were old layers (spent hens) were tested in the machine at five scalding temperatures (room temperature, 30, 50, 70 and 100°C). Results showed that feather retention rate and defeathering time decreased with increased operating speed, while plucking efficiency increased with speed.

The ANOVA test on the data collated shows the effect of defeathering speeds were insignificant. The scalding temperature had significant effect on the evaluation parameters while feather retention and defeathering time was seen to decrease with increase in scalding temperature. The plucking efficiency increases with increase in scalding temperature up to 700C and reduces afterwards. The highest plucking efficiency of 98.5% was obtained at 360 rpm rotor speed and 100°C scalding temperature. Based on physical evaluation and the results obtained, speeds of 280 rpm or higher were recommended to operate the machine and the scalding temperature of 70°C is recommended.

Indexed Terms- Poultry bird, Feather retention, Rotor speed, Defeathering, Scalding temperature, Plucking efficiency

I. INTRODUCTION

One of the most important aims of poultry production is to obtain meat and egg for consumption in various homes. As these meat products are being demanded for, cleanness and hygiene are highly expedient, hence the adoption of processing methods which are capable of delivering processed poultry product which are up to standard in terms of cleanliness and hygiene. Despite several important activities are involved in the production of ready-to-cook poultry products, a large percentage of the activities are labour intensive and resulted in a high cost of processed poultry meat in the market [1]. De-feathering takes the longest duration when done manually, it is tedious and limits the production per time and also allow much contamination due to touches on the skin [2]. Plucking machines, though existing in different designs and sizes in many developed countries, its presence in Nigeria is yet unpopular partly because of its cost or poor awareness of the poultry farmers on its functionality and operation parameters. Therefore, harnessing the mechanical defeathering process by designing, fabricating and evaluating an efficient, strong and easy-to-use de-feathering machine is expedient.

De-feathering involves removing feathers from the slaughtered birds. Traditionally, in this part of the world it is done manually by the use of hand after it has been soaked in hot water for a few minutes. This process results in low output, time-consuming, tedious and could lead to injury. In order to avoid all of these challenges, there is need to design and develop a de-feathering machine which is capable of optimizing the energy used during mechanical defeathering and also eliminating the drudgery involved in de-feathering process.

1.1 RELATED WORK

It takes an average time of 5minutes for a person to de-feather a bird while a bird which is lowered in hot water of about 80ºc – 85ºc will be defeathered within 40–50 seconds by a de-feathering machine. De-feathering machine saves time, easy to operate and better picking is achieved [3]. In order to enjoy production timeliness and drudgery free process of poultry bird de-feathering, it is imperative that a motorized de-feathering machine is developed and the effect of the rotor speed and scalding temperature is evaluated on feather retention and plucking efficiency

II. MATERIALS AND METHODS

2.1 Materials

For the testing of the machine, 30 *Isa brown* spent hens (old layer birds) were purchased from a reputable farm in Ilaro, Ogun State and were transported to the processing laboratory of Agricultural and Bio-Environmental Engineering department of the Federal Polytechnic Ilaro. The spent hens were fed up till the night before the experiment as it is the practice in slaughter houses. A temporary confinement was provided for the hens where they were placed before being picked up for the experiment. Other materials and equipment used during the research includes electronic weighing balance, thermometer, stop watch, measuring cylinder, thermostat, thermocouple, electric heater, water pump, electric motor, water pipes and a tachometer which was used during the calibration of the variable resistor system for effective speed regulation.

2.2 Design analysis

Area of the de-feathering chamber:

Factors considered in designing the de-feathering chamber are the length of a mature poultry bird, it ranges from (6-9 inches) $\cong$ 0.229m and the length of a Rubber Plucker which is 100mm (0.10m). The de-feathering chamber is cylindrical in shape, hence the formula to calculate the area of a cylinder is given in equation (1);

Area of a cylinder = $(2\pi r(r+h))$ (1)

According to equation (2), the diameter (D_{dc}) of the defeathering chamber is obtained from:

$(2 * L_{rp})$, i.e. 2 multiplied by the length of the Rubber Plucker plus the length of a mature poultry bird (L_{mb}).

$$Ddc = (2 \times Lrp) + Lmb + C \quad (2)$$

Where "C" is added as a clearance factor (C= 0.025m)

$(2\times0.10) + (0.229+0.025) = 0.2+0.229+0.025 = 0.454m$

Radius (r) = 0.227m

Area of the defeathering chamber is $2\pi r(r+h)$

$2\pi \times 0.227\ (0.227 + 0.41) = 0.908m^2$

The orthographic view of the defeathering chamber is shown in fig. 1 below, the components of the de-feathering chamber such as the rubber plucker, waste outlet, rotary plate and the clearance section are properly identified in the diagram.

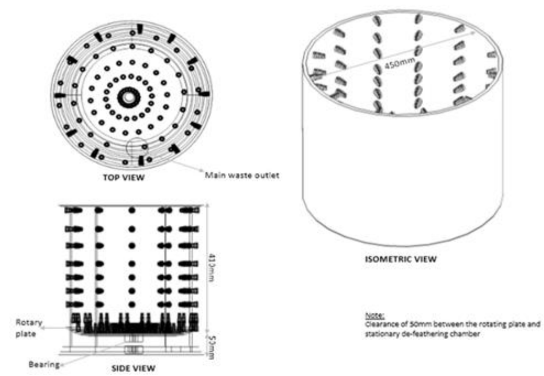


Figure 1. An orthographic view of the de-feathering chamber

Volume of the defeathering chamber

The defeathering chamber as shown in fig.2 is cylindrical in shape, to calculate the volume (V) of the defeathering chamber, Eq. (3) is used, where r is the radius and h is the height of the de-feathering chamber respectively.

$$V = \pi r^2 h \quad (3)$$

$V = \pi \times (0.227)^2 \times 0.41$

$V = 0.0664m^3$

Volume of the chamber is $0.0664m^3$

Volume of the three defeathering chamber = $3\times0.0664 = 0.1992m^3$

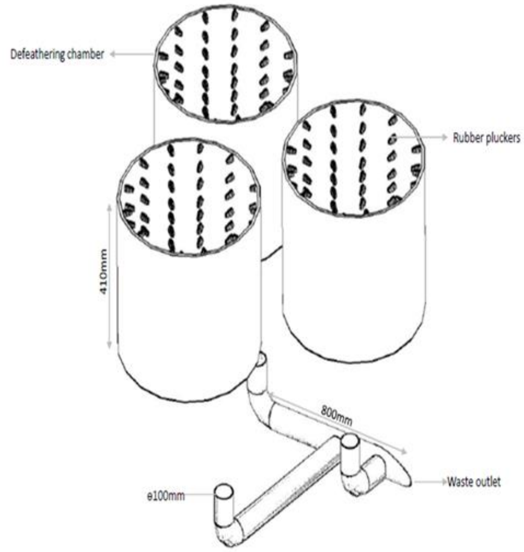


Figure 2. The three de-feathering chambers and waste outlet

- *Waste discharge outlet*

The waste discharge outlet is of the following specification, the outlet at the bottom plate of the de-feathering chamber is 0.11m x 0.06m while the diameter of the main waste outlet is 0.2m x 0.1m. Length of the main waste outlet is 0.8m

- *Hopper capacity*

The plucking chamber capacity is determined from the Eq. 4: [4]

$P_c = P\text{v}$ (4)

Where:

P is density of chicken sample (113kg/m³), V is the volume of the plucking chamber as determined from Eq. 3, Volume of a single chamber (V_1) is 0.0664m³

Volume of the three defeathering chamber ($(V1 + V2 + V3)$) is 0.1992m³

Plucking chamber capacity for the three defeathering chamber

$P_c = pV1 + pV2 + pV3$ (5)

$P_c = p\ (V1 + V2 + V3)$ (6)

$P_c = 113 \times 0.1992\text{m}^3 = 22.5096$ kg

Design of shaft

The shaft which will be made of stainless steel. Maximum shear stress theory was used for the design of shaft diameter and it is stated in Eq. 7, according to [5]

$$d_s = \frac{16}{\pi \tau_s}\sqrt{(K_b M_b)^2 + (K_t M_t)^2} \quad (7)$$

Where Kb is combine shock and fatigue factor applied to bending moment, Kt is combine shock and fatigue factor applied to torsional moment, Mb is Bending moment (Nm), Mt is Torsion moment (Nm) and τ is Allowable shear stress. Fig. 3 shows the prime mover and transmission system of the de-feathering machine

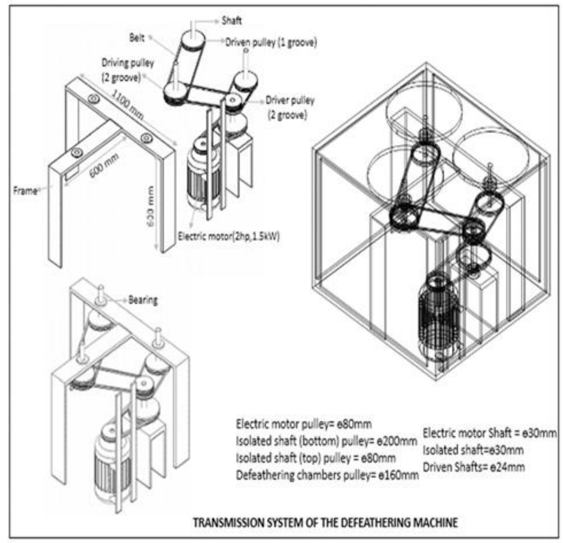


Figure 3. Transmission system of the de-feathering machine

- *Water pump*

The water pump is of 2hp rating, its major function is to pump heated water from the water reservoir through the pipes into the defeathering chamber where water is needed for scalding. The water flow design is shown in fig. 4 below.

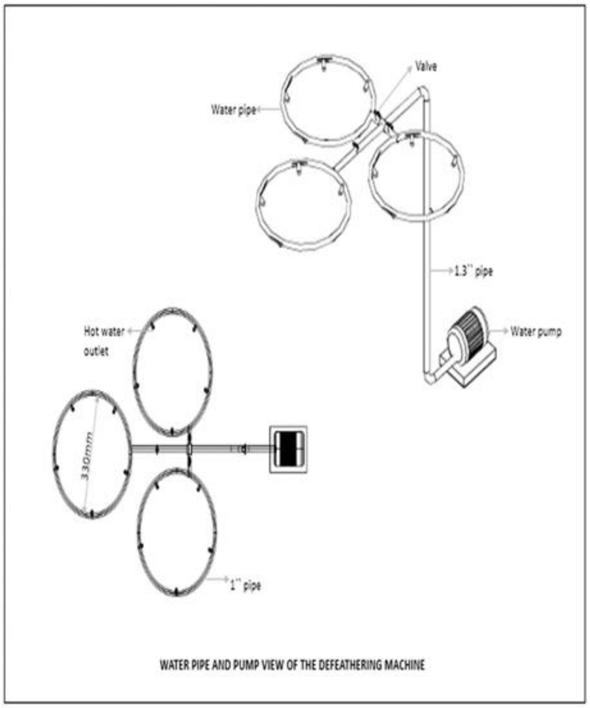


Figure 4. Water flow design from the pump to the point of discharge

- *Force required for feather removal*

The force required for feather removal Fc will be determined from the Eq. 8, [4]:

$$F_c = M\omega^2 r \quad (8)$$

Where M is the mass of the rotating plate, ω is the angular velocity of the pulley and r is the pulley radius.

- *Power requirement of the machine*

The total power (Pt) requirement of the machine is the sum of the power required to rotate the de-feathering plate (Pr) and the power required to defeather (Pd) the chicken. It is represented in Eq. 9 according to [4]:

$$P_t = P_r + P_d \quad (9)$$

Power required to rotate the de-feathering plate (P_r): The power required to rotate the feather plate is determined by Eq. 10 according to [4]:

$$P_r = W_p R_p \omega_p \quad (10)$$

Where W is the weight of rotating plate (kg), Rp is the radius of the rotating plate (m)

ωp is the angular velocity of the rotating plate (rad/s). Note that ωp is 2πN/60, where N is the revolution per minute of the rotating plate.

Power required to defeather (P_d): Power required to de-feather the bird is determined with Eq. 11 according to [4]:

$$P_d = T_s \omega_d \quad (11)$$

But, $T_s = \pi d^3 \tau / 16$ (12)

Where Pd is the power required to de-feather the bird, Ts is the torque of the defeathering chamber

ω_d is the angular velocity of the de-feathering chamber, D is the mean diameter of the de feathering chamber and τ is the shear stress of the de-feathering chamber.

- *Electric motor*

After proper consideration of the force required for feather removal and the power requirement of the de-feathering machine, a single-phase electric motor of 2HP, 1.5Kw rating which has 1500 revolution per minute was used for this design.

- *Shear failure analysis of the de-feathering chamber*

The shear stress of the defeathering chamber is determined by Eq.13, according [4]:

$$\tau = 16Mt/\pi d^3 \quad (13)$$

Mt= WR

Where W is the weight of the chamber (kg), Mt is Torsional moment (Nm) and R is mean diameter of the chamber (m). The isometric and exploded view of the de-feathering machine are shown in fig. 5 and fig. 6 respectively.

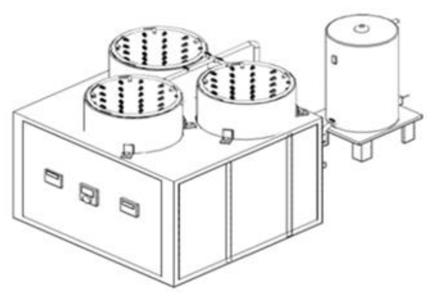


Figure 5. Isometric view of the De-feathering machine

2.3 Experimental Method

The slaughtered birds were dipped into the scalding water for a period of one minute and constant for all experiments. The slaughtered birds were weighed on a digital scale before scalding, and the scalded birds were also weighed before they were de-feathered. The remaining feathers on the birds were removed by hand and weighed to quantify the percentage feather remaining on the birds. The final weight of carcass was also recorded. This same procedure was repeated for all scalding temperatures and feather plate speeds (rotor speed).

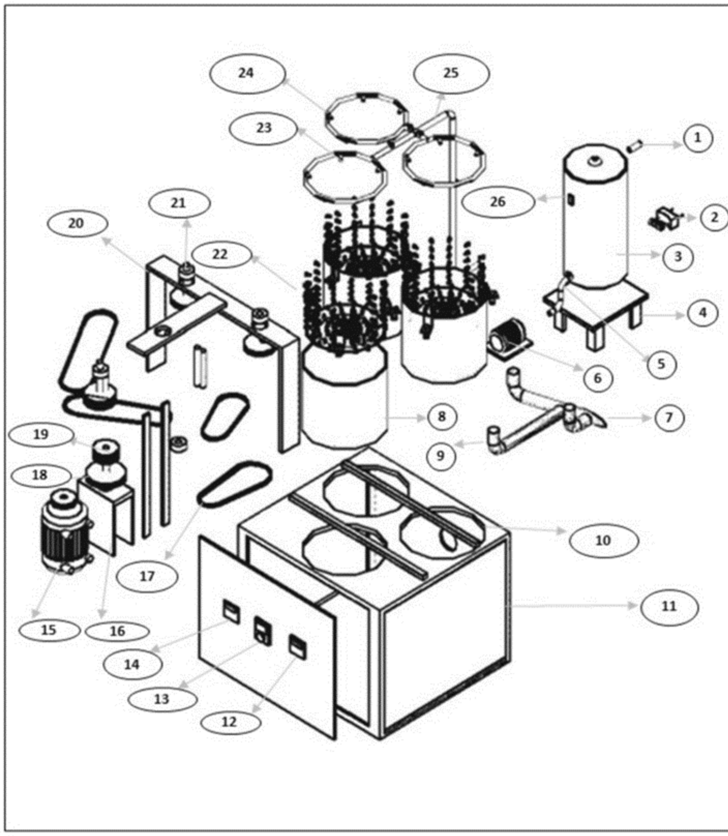
Five different scalding temperature was used to evaluate the effect of scalding temperature on de-feathering. The temperatures are room temperature (RT, 25-26^{0}C), 30^{0}C, 50^{0}C, 70^{0}C and 100^{0}C. After scalding the birds for one minute, the birds were placed in the defeathering chamber and de-feathering commences immediately while water of the same temperature as the one used for scalding was continuously pumped into the de-feathering chamber throughout the de-feathering operation. The de-feathering machine was powered by a 2hp, 1.5Kw electric motor of 1500 revolution per minute. The effect of feather plate speeds (rotor speed) was also evaluated on de-feathering. Three speeds (360 rpm, 280 rpm and 200 rpm) were used to determine if rotor speed affects feather retention and de-feathering efficiency.

i. Feather retention (λ) (%) is given as;

$$\lambda\,(\%) = \frac{M_{fh}}{M_{fh}+M_{fm}} X\ 100 \quad (14)$$

ii. Plucking (Feather Removal) Efficiency (η) can be determined with the equation below [6].

$$\eta\,(\%) = \frac{M_{fm}}{M_{fh}+M_{fm}} X\ 100 \quad (15)$$



Items	Description	Qty	Dim(mm)	Items	Description	Qty	Dim(mm)
1	Water Source	1		14	Speed Regulator	1	
2	Heater	1	1.5kW	15	Electric Motor	1	2.5hp
3	Water tank	1	7200mm^3	16	Isolated shaft frame	2	100x100
4	Tank Stand	1	600x600	17	Belt	4	300
5	Tap	1		18	Isolated driven pulley	1	600
6	Water Pump	1	2 hp	19	Isolated Driving pulley	1	ø400
7	Main waste Outlet	1	ø300	20	Transmission frame	1	50
8	Defeathering Chamber	3	600x400	21	Shaft and Bearing	3/6	
9	Waste outlet	3	ø300	22	Rubber Pluckers	450	50
10	Defeathering port	3	ø400	23	Water Pipe	3	1.5 inches
11	Defeathering chamber frame	1	1200x1000x900	24	Water Discharge Outlet	15	
12	Main switch	1		25	Pump Pipe	1	1.5 inches
13	Water Temperature Regulator	1		26	Thermocouple	1	

DIM: mm
SCALE: 1:3

Figure 6. Exploded view of the defeathering machine

M_{fh} is Mass of feathers removed by hand after de-feathering and M_{fm} is Mass of feathers removed by the defeathering machine

III. RESULTS AND DISCUSSION

Descriptive analysis of the evaluating parameters (feather retention, plucking efficiency and the defeathering time) in respect to the varied operating parameters (feather plate speed (rpm) and scalding temperature 0C) are shown in the table 1 below.

Where: Wd is dry weight of slaughtered bird before scalding (g), Ww is wet weight of slaughtered bird after scalding (g), Wad is weight of bird after defeathering (g), Wfm is weight of feathers removed by the machine (g) and Wfh is weight of retained feathers on de-feathered bird which was removed by hand (g). Fig. 7 shows the process of measuring the weight of the bird before and after de-feathering operation.

(a) Before de-feathering (b) After de-feathering
Fig.7: Scalded bird and Carcass being weighed before and after de-feathering respectively

3.1 Effect of rotor speed on feather retention

Fig.8, shows the effect of feather plate speed (rotor speed) on the quantity of feather retained. At 200 rpm, 17.3% of the total feathers on the bird was retained after subjecting it to the defeathering operation at 30°C scalding temperature. This reduced to 13.4% at 280 rpm and 8.4% at 360 rpm. At 70°C scalding temperature, rotor speed was also seen to affect the rate of feather retention as the percentage of feather retained decreases from 5.8% to 2.9% for 200 rpm and 280 rpm respectively. The major trend that was observed is the reduction in the percentage of feather retained as the scalding temperature and rotor speed increases, however there are few exceptions to this condition. At 70 0C and 280 rpm, the percentage of feather retained was 2.9% when de-feathering operation was carried out under 52 seconds while the percentage of feather retained was 4.2% when de-feathering was done at 360 rpm, 70 0C scalding temperature and 36 seconds retention time. This alteration in the trend explains that feather retention is not only a function of the rotor speed and scalding temperature but defeathering time (retention time) also has a significant effect on the percentage of feather retained.

The percentage of feather retained also decreases with increase in speed when the bird was subjected to scalding at 50^0C, the percentage of feather retained are 8.8%, 6.9% and 2.5% at 200, 280 and 360 rpm respectively. This occurrence is explained to be a result of lower torque generated at the lower speeds which could be lower than the force required to pluck the contour parts of the birds. [1] Explained that higher plucking force were required to remove feathers at the contours in comparison with the down or extended body feathers. This affirms the assumption that most of the feathers removed by hand after the mechanical de-feathering process were the contour feathers. More of these were present at the room temperature scalding and this was confirmed by [1], whose research work also revealed that higher plucking force was required at lower temperatures in comparison with higher temperatures close to 70°C.

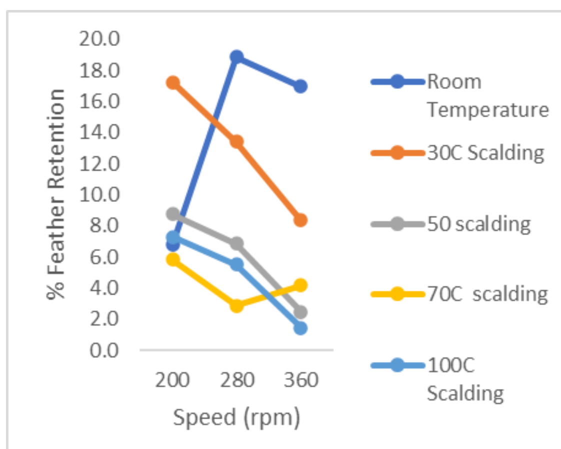


Fig. 8: Effect of rotor speed on feather retention

Table 1: Descriptive Statistics of Evaluation Parameters

Speed	Temp(°C)	W_d (g)	W_w (g)	W_{ad} (g)	W_{fm} (g)	W_{fh} (g)	W_{fm}+W_{fh} (g)	λ (%)	ŋ (%)	T (min)
	RT	1430.0	1577.2	1312.2	265.0	19.3	284.3	6.8	93.2	6.02
	30	1265.5	1395.1	1163.7	231.4	48.3	279.7	17.3	82.7	5.21
200	50	1212.7	1355.1	1094.2	260.9	25.1	286.0	8.8	91.2	3.21
	70	1138.7	1099.5	883.2	216.3	13.4	229.7	5.8	94.2	3.56
	100	1124.4	1246.8	1054.0	192.8	15.2	208.0	7.3	92.7	0.59
	RT	1317.0	1425.2	1342.2	83.0	19.3	102.3	18.9	81.1	5.02
	30	1380.2	1502.1	1163.7	338.4	52.4	390.8	13.4	86.6	4.13
280	50	1114.2	1265.1	1110.5	154.6	11.4	166.0	6.9	93.1	1.39
	70	1301.2	1431.0	1251.3	179.7	5.3	185.0	2.9	97.1	0.52
	100	1164.1	1246.8	1051.6	195.2	11.4	206.6	5.5	94.5	0.45
	RT	1301.0	1412.3	1307.0	105.3	21.5	126.8	17.0	83.0	3.51
	30	1672.0	1802.0	1582.0	220.0	20.1	240.1	8.4	91.6	3.22
360	50	1098.0	1217.0	1067.0	150.0	3.8	153.8	2.5	97.5	2.05
	70	1308.5	1449	1286.0	163.0	7.1	170.1	4.2	95.8	0.36
	100	1272.0	1435.0	1118.0	317.0	4.7	321.7	1.5	98.5	0.25
Mean	50.00	1273.30	1390.61	1185.77	204.84	18.55	223.39	8.46	91.54	2.63
St. Dev	35.25	149.20	168.70	166.29	71.29	14.50	78.27	5.60	5.60	1.97

3.2 Effect of rotor speed on plucking efficiency

The effect of feather plate speed (rotor speed) on plucking efficiency of the machine is shown in Fig.9, Plucking efficiency increased with increasing speed as lower quantity of feathers were retained on the carcass. This performance is however attributed to the scalding temperature but it was observed that at 200 rpm speed of the feather plate, the lowest plucking efficiencies of 82.7%, 91.2%, 92.7%, 93.2% and 94.2% were obtained while efficiencies of 81.1%, 86.6%, 93.1%,94.5% and 97.1% were obtained at 280 rpm speed. However, at 200 rpm and room temperature (scalding temperature), the plucking efficiency was 93.2% at 6.02 minutes retention time while de-feathering operation carried out under the same rotor speed (200 rpm) at 100 °C scalding temperature and 0.59 seconds retention time resulted in a plucking efficiency of 92.7%. This reduction in plucking efficiency occurs as a result of decrease in retention time, if the retention time had been increased further, let's say by 30 seconds, it can be presumed that plucking efficiency at 100 °C scalding temperature would surpass that of the room temperature when examined under 200 rpm rotor speed.

In as much as it can be deduced that increase in scalding temperature or rotor speed gives a corresponding increase in plucking efficiency, this condition is subject to the fact that varying the retention time under any subsequent increase in speed or scalding temperature also have a major role to play on the plucking efficiency. This discovery negates the results obtained by [6], who observed that a decrease in plucking efficiency will occur with an increase in speed above 200 rpm. However, this result affirms the discoveries of [4] who observed that an increase in defeathering speed will produce a corresponding increase in plucking efficiency.

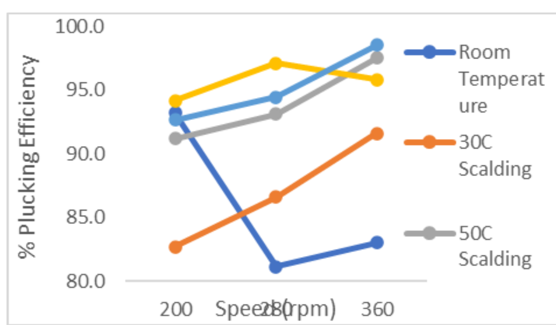


Figure 9. Effect of rotor speed on plucking efficiency

3.3 Effect of rotor speed on de-feathering time

The time taken for complete removal of the feathers on the birds subjected to the test was seen to decrease with increased speed. As shown in Fig.10, the times taken to de-feather the birds at 200 rpm were 6.02 minutes, 5.21 minutes, 3.56 minutes, 3.21 minutes, and 0.59s for the varying scalding temperatures (RT, 30°C, 50°C, 70°C and 100°C). Decrease in de-feathering times were obtained for as low as 25 seconds at 100°C scalding temperature as the speed of the rotor speed was increased further from 280 rpm to 360 rpm. During the evaluation at higher de-feathering speeds (280 rpm , 360 rpm) and scalding temperatures (70°C, 100°C), it was observed that most of the down feathers were removed within 10 -15s while the contour feathers took longer time before they were de-feathered.

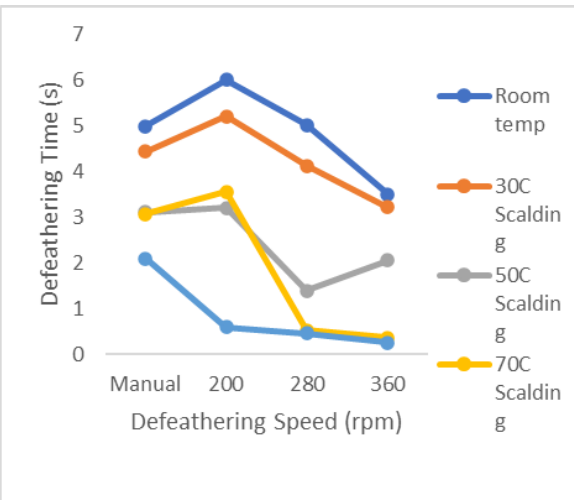


Figure 10. Effect of rotor speed on de-feathering time

3.4 Effect of scalding temperature on feather retention

Ref. [1] reported that for both species (matured local and exotic chickens) of birds subjected to test, and for both down and contour feathers, the forces required to pluck the feathers reduced with increase in temperature. the scalding temperature was raised from "50 -55-60-65-70-75-80-85 90°C". They observed that "the temperature at which the exotic bird was appropriately de-feathered is within the range of 60°C - 70°C. This same phenomenon was repeated in this experiment as seen in fig.11, the rate of feather retention was observed to reduce as the scalding temperature increases.

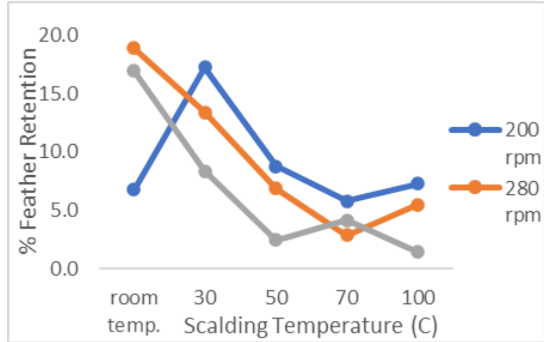


Figure 11. Effect of Scalding temperature on feather retention

3.5 Effect of scalding temperature on plucking efficiency

Fig.12 shows the effect of scalding temperature on the plucking efficiency. At room temperature (RT) scalding, the lowest plucking efficiencies of 81.1 and 83.0% were obtained for 280 rpm and 360 rpm speeds de-feathering respectively. These further increased to 82.7, 86.6 and 91.6% at 30°C scalding temperature up to 92.7, 94.5, and 98.5% at 100°C. It was however observed that there is a tendency for reduction in the plucking efficiency at temperatures higher than 70°C if the retention time is not properly adjusted. At 100°C scalding temperature and 360 rpm rotor speed, the plucking efficiency increased to 98% within 25 seconds retention time, this shows that better plucking efficiency can be achieved at higher scalding temperature provided the retention time is appropriately varied. Fig.13 shows the pictorial view of the de-feathering machine and fig.14 shows the inner part of the de-feathering chamber, this inner part consists of the rubber pluckers and the rotating plate.

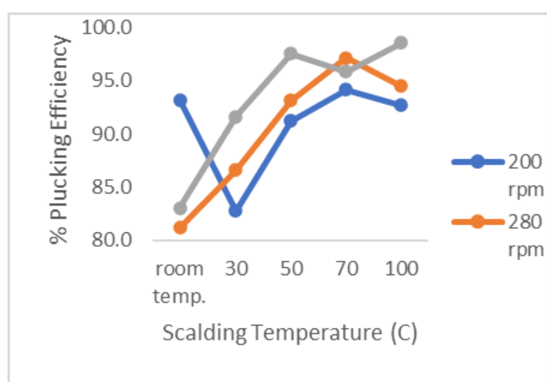


Figure 12. Effect of Scalding temperature on plucking efficiency

Figure 13. A pictorial view of the fabricated defeathering machine

Figure 14. Inner part of the defeathering chamber (rotating plate and rubber pluckers)

3.6 Physical Evaluation of Recovery and Mechanical Damage in plucked birds.

Physical evaluations of the birds plucked were conducted to check for tears and breakages in the de-feathered birds. At all scalding temperatures the machine inflicted no tears on the de-feathered birds. At the highest speed tested (360 rpm), there was no breakage since the birds were quickly de-feathered and discharged. However, the heads of the birds were mostly detached from the body due to high de-feathering speed. At the low speed of 200 rpm, the heads were intact but the birds had a prolonged stay in the plucking chamber, this increased retention time led to breakage of some bone especially on the birds scalded at temperatures below 50ºC. Hence, it can be recommended that, for adequate material recovery a rotor speed of 280 rpm should be adopted if the head is needed on the body but if otherwise, 360 rpm would be adequate.

3.7 Statistical Comparative Analysis of the factors affecting Machine's Performance

A summary of the ANOVA test was carried on all evaluated parameters as presented in Table 2.

It was observed from the ANOVA results that the rotor speed does not have a significant effect on feather retention, plucking efficiency and de-feathering time as the values of 0.720, 0.720 and 0.326 were obtained at $P<0.05$ significance level. However, the scalding temperature had a significant effect on the machine operation and result obtained as the values of 0.033, 0.033 and 0.004 were obtained for feather retention, plucking efficiency and de-feathering time respectively. This is an affirmation to the graphs plotted earlier which depicts that scalding temperature affected the parameters.

3.8 Regression modelling for evaluation parameters

To check for the relationship between the speeds of the feather plate, the birds' characteristics in terms of weight and the scalding temperature in respect to the plucking efficiency, feather retention and the plucking time regression models, the form Y= A+ bX were derived using the SPSS regression analysis test, where: λ represent Y, A represent intercepts and b is the coefficient of speed, scalding temperature and weight of bird

The regression analysis carried out for *feather retention* given the relationship to be;

$\lambda = 22.345 - 0.01S - 0.12T - 0.003Wd$ (16)

The model had a R^2 value of 0.533 and standard error of 4.31. The model indicates that the machine speed, the scalding temperature and the weight of the bird have an inverse relationship with the proportion of feather retention experienced; this was accounted for by the negative sign. However, this model can only explain these relationships at 53% correctness. It therefore implies that there could be other parameters that may account for the feather retained during the operation.

The model for *Plucking Efficiency (*ŋ) is given as:

$ŋ = 22.345 - 0.01S - 0.12T - 0.003Wd$ (17)

while the relationship for the *Defeathering time* is given by

$$t = 6.395 - 0.01S - 0.04T - 0.001Wd \quad (18)$$

With an R-square value of 0.88 which implies that this model explains 88% of the phenomenon experienced and thus can be predicted adequately by the model. It also reveals that the speed of operation, the weight of bird and the scalding temperature all have an inversely proportional relationship with the de-feathering time.

Where: λ is the feather retention (%), η is Plucking efficiency (%), t is defeathering time (s),

S is the rotor speed (feather plate speed) in rpm., T is the scalding temperature (^{0}C) and Wd is Dry weight of slaughtered bird (g)

Table 2: Summary of ANOVA results for the evaluated parameters

		Speeds	Scalding temp
Feather Retention	Significance	0.720	0.033
	Comment	Not Significant	Significant
Plucking efficiency	Significance	0.720	0.033
	Comment	Not Significant	Significant
Defeathering time	Significance	0.326	0.004
	Comment	Significant	Significant

IV. CONCLUSIONS AND RECOMMENDATIONS

The chicken feather plucking machine was designed, fabricated and its performance was tested. Three speeds of 200, 280 and 360 rpm were adopted and 5 scalding temperatures which are the room temperature (25-26^{0}C), 30°C, 50°C, 70°C, and 100°C were adopted for birds scalding before they were defeathered. Results obtained showed that the feather retention decreased as the speed increased but the ANOVA result of 0.72 shows that speed has no significant effect on feather retention. This also applies to the plucking efficiency. However, the highest plucking efficiency of 98.5% was obtained at 360 rpm speed and 100°C scalding temperature. Based on the physical evaluation and the results obtained speeds of 280 rpm or higher were recommended to operate the machine and the scalding temperature of 70°C is recommended. On a general note, the machine functioned well and inflicted minimal or no damage on the processed birds. However, further research should be carried out to evaluate the effect of retention time on plucking efficiency and mechanical damage during de-feathering operation.

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